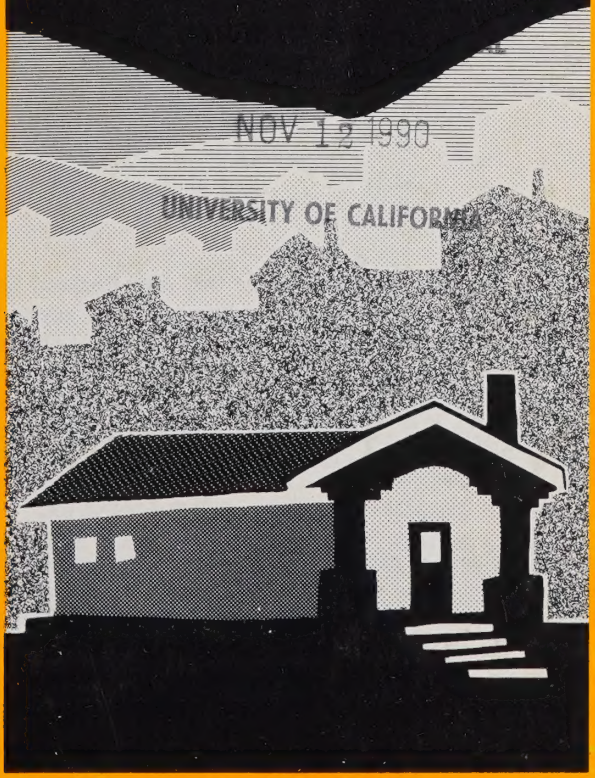
home buyer's guide to earthquake hazards



This booklet has been developed by the Bay Area Regional Earthquake Preparedness Project (BAREPP) to introduce home sellers and home buyers to common earthquake hazards encountered in older homes. It is intended as a checklist to assist in making informed choices in the selection and purchase of single family residences. However, it is not possible to identify every potential hazard. This booklet is not, nor is any other checklist, a substitute for evaluation of a structure by a licensed structural engineer or architect, or for evaluation of a site by a licensed geologist or soils engineer.

Because the science of earthquake engineering is not sufficiently developed to enable precise prediction of an earthquake's consequences, there can be no guarantee that application of the information in this booklet will safeguard people and property in an earthquake. The information in this publication has been carefully reviewed, but neither the authors, the reviewers, FEMA, nor the State of California assumes liability for any injury, death, or property damage that occurs in connection with an earthquake.

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home buyer's guide to earthquake hazards

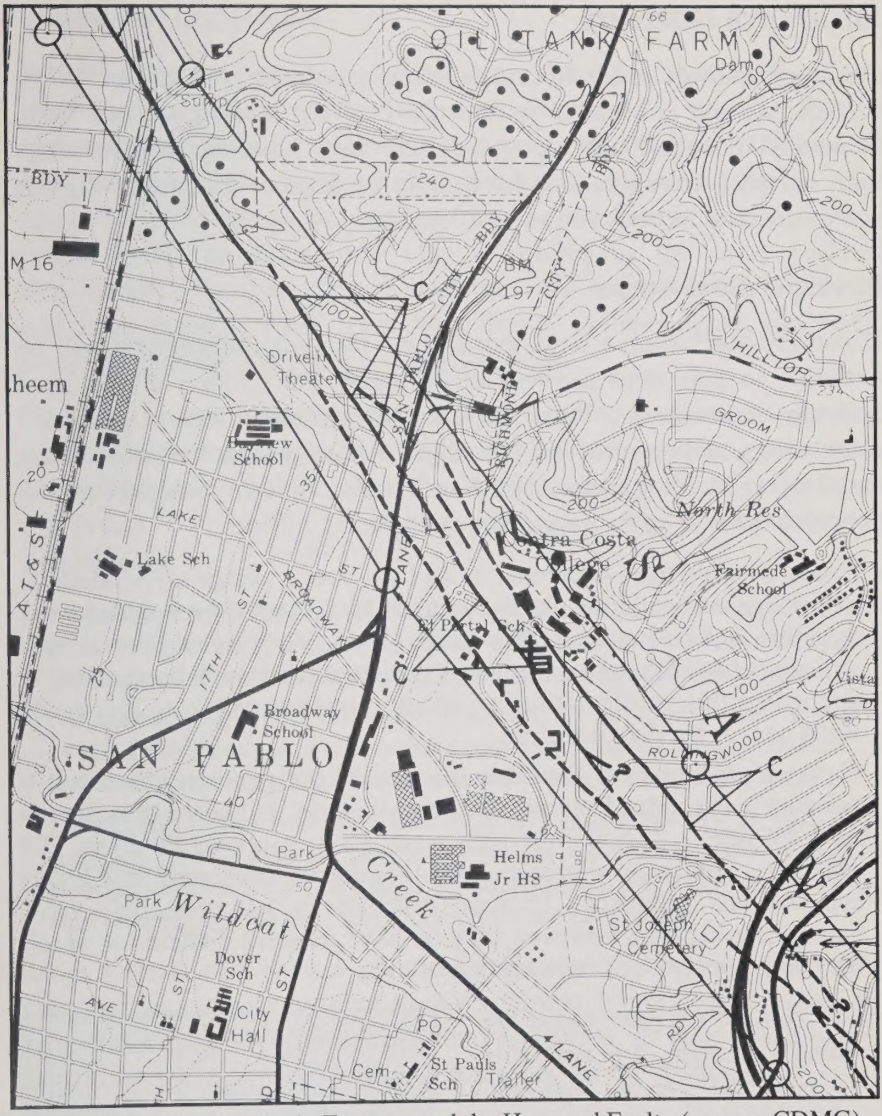
When you walk into that dream house, earthquake safety is probably the last thing on your mind. Nevertheless, it is something you must consider for the protection of your family and home. This pamphlet outlines some common hazards found in wood frame houses and describes how you can identify them.

Geologic Hazards

Geologic hazards affect the site of a house. Most people associate geologic hazards with the proximity of the house to an earthquake fault. Although proximity to a fault is a major concern, strong ground shaking associated with unstable soils can occur miles from an earthquake epicenter. Following are some hazard areas that you should be aware of:

- ***Fault zone*** -- Quarter-mile-wide Special Study Zones have been designated around major earthquake faults. In a big quake, the ground in these zones has a greater potential to rupture. Structures in these zones may suffer major damage, especially if they are built astride a fault trace. Maps of these Special Study Zones areas can be obtained from the California Division of Mines and Geology or the local building department.
- ***Geologic hazard zones*** -- These are areas where intense ground shaking, settlement, landsliding, or liquefaction (earthquake induced flow of water-saturated sandy soils) may occur in a large quake. Soft and unstable soils will magnify earthquake forces and damage structures. Earthquakes also can cause unstable soil to move and erode, which may be more damaging than shaking. Maps showing these areas are included in the San Andreas and Hayward Fault Scenario Studies and can be obtained from the California Division of Mines and Geology. The United States Geological Survey and the Association of Bay Area Governments have similiar studies. Many urban areas have county geologists who may have specific data on stability of building parcels. If there is a history of landsliding, settlement, or major soil problems on your parcel, the county geologist will have a record of it.
- ***Flood and inundation zones*** -- Areas that are subject to inundation by potential ruptures of dams and reservoirs in a large earthquake have also been mapped. Maps showing these areas can be obtained from local city or county planning departments as well as from the California Office of Emergency Services.

In addition to the above sources, you may want to seek professional advice on potential geologic hazards. If your land parcel has been cut or filled and a soils report is available, it is a good idea to consult a soils engineer to review the report and to ensure the quality of the earthwork. If your parcel is on a natural slope, you may want to confer with a engineering geologist on potential slope stability problems.



Map showing Special Study Zone around the Hayward Fault. (source: CDMG)

C

active fault, **C** indicates displacement caused by creep

approximately located fault

inferred fault

concealed fault, **?** indicates uncertainty

special study zone boundary

Structural Hazards

Structural hazards result from a building's inability to withstand a big earthquake, and are related to how the building is designed and built. Generally, older buildings are weaker than newer buildings, and buildings with complex configurations have more problems. The following are some structural hazards you should consider.

Buying A New House

If you are purchasing a new house, some technical information will be available to you from the real estate agent, the builder, or the local building department. This may include a soils report, structural calculations, and construction drawings. Although new houses are built under recent building codes, some new houses still have potential flaws in their resistance to earthquakes. For example:

- ***House over garage*** -- Second stories built over a garage are vulnerable to damage and collapse. Many garages have large door openings and therefore lack resistance to earthquake forces. The ground floor in such structures has collapsed in previous earthquakes. It may be possible to strengthen this configuration by adding plywood panels to the inside walls next to the door opening.
- ***Unusual structures*** -- Building shape and configuration can affect a building's strength. Unusual structures include: 1) houses on stilts (as on a hillside), 2) buildings with many large windows or doors, 3) structures with large overhangs, and 4) buildings with many split levels and complex geometry. Unusual structures do not necessarily have earthquake hazards; however, they do have inherent difficulties which may be overcome by structural engineering.

When you are not sure about the building's strength, it is advisable to visit the local building department and talk to the engineer who reviewed the house plans. If you still have doubts, consult an architect or structural engineer who is familiar with earthquake design and obtain a review of the construction drawings and/or an inspection of the house.

Collapse of a house over garage in the 1971 San Fernando earthquake.

Buying An Old House

When buying a previously occupied house, check for the possible hazards listed below as well as the hazards listed for new houses. This is especially important if you are buying a house built before 1960, because older buildings often were not designed to withstand earthquakes. The age of the building can be obtained from the tax assessor's file, your real estate agent, or a Sanborn map (available at the local building department). There are other sources too, such as the building permit file and utility records. After determining the age of the building, you should carefully examine it for structural deficiencies.

The place to start your inspection is at the foundation. Some houses have concrete slab foundations, which should perform well in earthquakes. Most older houses have exterior foundation walls around the perimeter of the house. Perimeter foundations may have any of the following deficiencies:

- ***Unreinforced foundation***-- Buildings built before 1940 may have unreinforced brick foundations, which can come apart in an earthquake. Unreinforced brick foundations should be strengthened or replaced.
- ***No foundation*** -- In some older buildings, the foundation may not exist at all. In this case, a new foundation must be constructed to connect the structure to the ground. This may involve a major reconstruction.
- ***Detached footing*** -- Some older buildings may rest only on individual footings (piers) that are not connected to each other. Because these structures have little resistance to earthquakes. Again, major foundation repairs may be necessary to remedy the problem.

Most houses will have a concrete perimeter foundation. The most common and most important hazard in wood frame houses is that the structure may not be connected to the foundation. If your house is built on a concrete slab, it is probably connected to the foundation. If your house has a perimeter foundation, you should go into the crawl space to check the following:

- ***No foundation bolts*** -- Many older structures built before 1940 are not bolted to the foundation. In a large earthquake, the building may slide off its foundation, causing major damage. To remedy this situation, anchor bolts can be added to bolt the mud sill to the existing foundation.
- ***Unbraced cripple wall*** -- Houses will often have short walls--known as cripple walls--between the first floor and the foundation. Many cripple

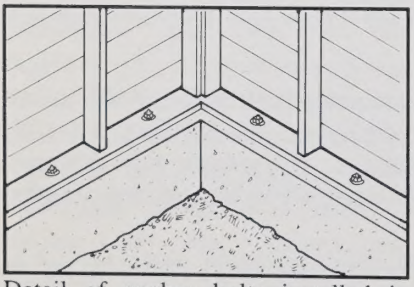
walls are not adequately braced. With a weak cripple wall, a building can shift sideways in an earthquake and collapse downward. The cripple wall can be strengthened by adding plywood panels to the inside.

While you are in the crawl space, you should check for two other items. First, you should see if there is any rot or termite damage that will weaken the structure. You should also check to see if there are any large cracks in the foundation. Cracks in a newer house can mean that the soil under the house has moved and is unstable or that drainage is inadequate.

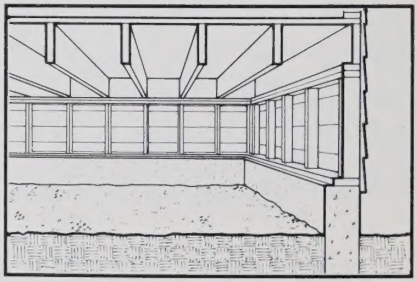
The next step in the inspection is to look at the main part of the house:

- ***Renovation*** -- Look to see if the house has been renovated. Have any interior walls been removed? Have large openings, such as doors and windows, been cut in walls? Are there additions to the house? If renovations were not done with earthquakes in mind, they may weaken a structure. Check with the local building department to see if appropriate permits for the addition or alterations were obtained.
- ***Settlement*** -- If the house is on a sloping site, check for cracking plaster, slanting floors, and crooked doorways. One way to recognize a slanting floor is to put a marble in the middle of each room and see if the marble rolls. A newer house with these problems may indicate recent soil settlement.
- ***Porches and balconies*** -- Are there large porches, overhangs, or balconies? These exterior portions of the structure may not be adequately attached to the house and can collapse in an earthquake.
- ***Heavy roof --*** Heavy roofing material such as clay or slate tiles can fall off the roof during an earthquake. A heavy roof can also generate large earthquake forces that can cause structural damage.

If you suspect that the house has substantial structural hazards, consult an architect or engineer experienced in earthquake design for a detailed inspection.



Detail of anchor bolts installed in place.



Interior view of the cripple wall area.

Nonstructural Hazards

Finally, you should look for hazards that are not a part of the house's structure, but can still harm you and your family in a big quake. Some common nonstructural hazards are:

- ***Weak chimney*** -- Does the house have a brick chimney that extends several feet above the roof, or stands against an exterior wall? If your house was built before 1934 and has this type of chimney, the chimney may collapse in an earthquake.
- ***Hazardous trees*** -- Are there large, old, or leaning trees around the building that may topple in a big quake? Check for root rot or dead branches that may fall.
- ***Unstable water heater*** -- Is the water heater strapped to the wall? If not, it can topple in a quake and cause a fire.
- ***Large glass areas*** -- Large windows and skylights are nice, but if there is little wall area bracing the opening, the glass can shatter in an earthquake. Tempered or wire-reinforced glass, or a layer of shatter-resistant film, can keep the glass from breaking into slivers.
- ***Light fixtures*** -- Are the light fixtures heavy or made of glass? If so, they can fall in an earthquake and may need to be replaced.

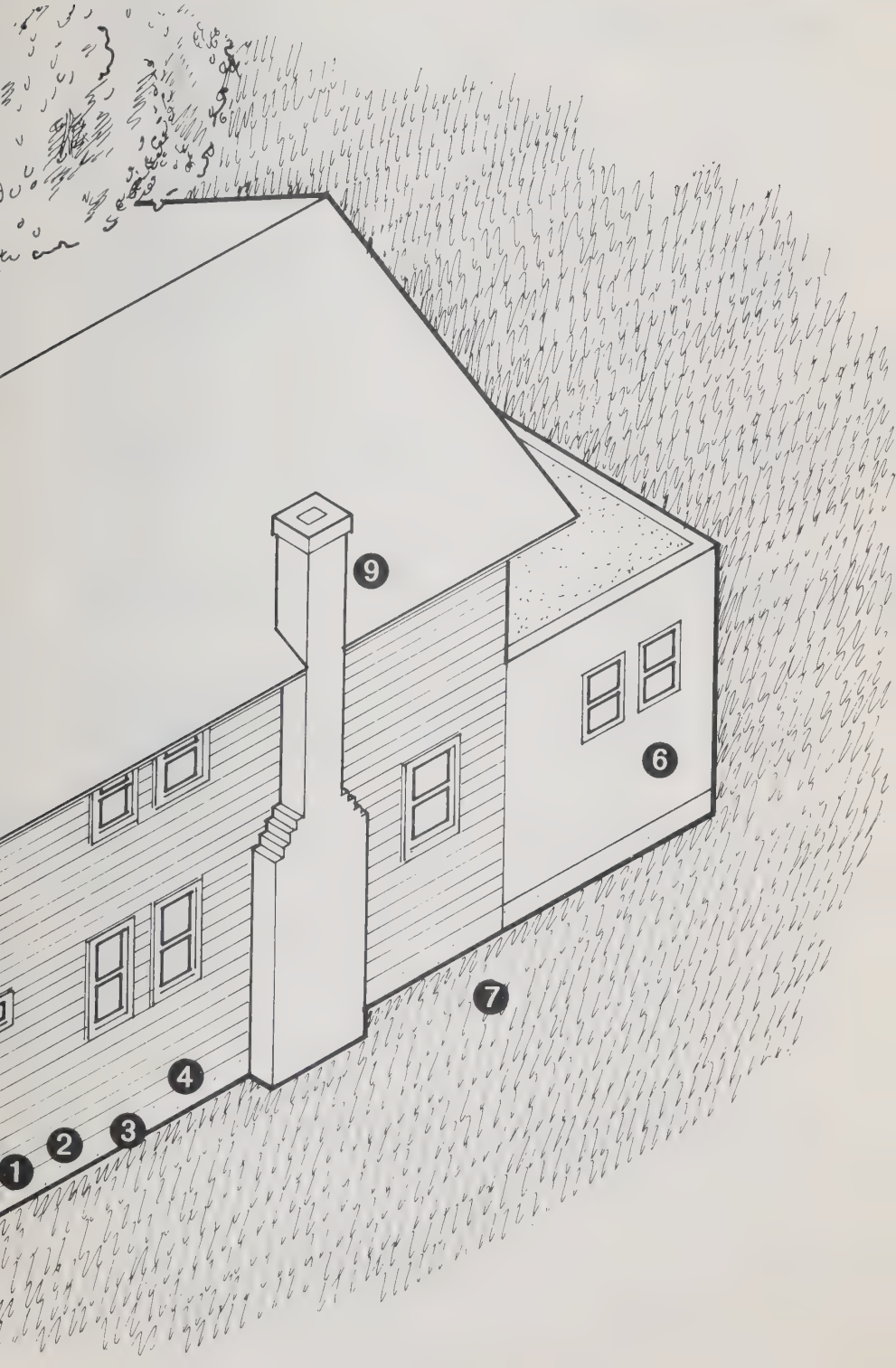
After your inspection of the house, you should have a list of potential hazards. Some hazards can be easily remedied, while others may be costly and affect your decision to buy. If you do decide to purchase a house with a few potential hazards, it is important to follow through and fix the deficiencies as soon as you close the deal.

You should also remember not to add hazards to your house after you have moved in. When you decorate your new home, keep earthquakes in mind. Put heavy or breakable objects in places where they will not fall or break. Bolt tall bookcases, cabinets, and appliances to the wall. Secure large pictures or mirrors to structural members with closed-eye bolts. If you renovate your house, the remodeling should not weaken the structure.

Make sure your dream house doesn't become a nightmare in an earthquake.

Places to Check for Hazards

1. unreinforced foundation
2. no foundation
3. detached footing
4. no foundation bolts
5. unbraced cripple wall
6. renovation
7. settlement
8. porches and balconies
9. weak chimney
10. weak trees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Geologic Checklist

- ❒ **Fault zone** -- Is the property in a Special Study Zone?

- ❒ **Geologic hazard zone** -- Is the property in an area where intense ground shaking, liquefaction, landsliding, or settlement may occur in an earthquake?

- ❒ **Flood zone** -- Is the parcel in an area that may be inundated after an earthquake?

Structural Checklist

- ❒ **House over garage** -- Are there living areas over the garage?

- ❒ **Unusual structure** -- Does the structure have unusually tall stories, long spans, or complex geometry?

- ❒ **No foundation** -- Does the house have a foundation?

- ❒ **Unreinforced foundation** -- Does the house have an unreinforced masonry foundation?

- ❒ **Detached footing** -- Is the house supported only by detached footings?

- ❒ **No foundation bolts** -- is the sill plate bolted to the foundation?

- ❒ **Unbraced cripple wall** -- Is the cripple wall weak and in need of bracing?

- ❒ **Renovation** -- Has the structure been previously altered?

- ❒ **Settlement** -- Has the soil under the house moved or slid?

- ❒ **Porches and balconies** -- Are these elements structurally attached to the house?

- ❒ **Heavy roofs** -- Are there heavy roofing materials such as clay or slate tiles that can fall in an earthquake?

Nonstructural Checklist

- ❒ **Weak chimney** -- Does the house have an old brick chimney?

- ❒ **Hazardous trees** -- Are there precarious trees near the house that may fall during an earthquake?

- ❒ **Unstable water heater** -- Is the water heater strapped to the wall studs?

- ❒ **Large glass areas** -- Are there large glass areas unbraced by walls?

- ❒ **Light fixtures** -- Are there heavy or glass light fixtures that can fall?

- ❒ **Large Mirrors** -- Are there large mirrors or heavy hangings that are not well secured to the structure?

Information Sources

Geologic maps and studies

- California Division of Mines and Geology
  660 Bercut Drive
  Sacramento, CA 95814
  (916) 445-5716
- United States Geological Survey
  Building 3, Room 504
  345 Middlefield Road
  Menlo Park, CA 94025
  (415) 883-8300
- Association of Bay Area Governments
  P.O. Box 2050
  Oakland, CA 94604-2050
  (415) 464-7900
- Bay Area Regional Earthquake Preparedness Project
  101 8th Street, Suite 152
  Oakland, CA 94607
  (415) 540-2713

Information on specific land parcels

- Local Building and Planning Department
- Local Department of Public Works
- County Geologist

Preparedness information

- Bay Area Regional Earthquake Preparedness Project
  101 8th Street, Suite 152
  Oakland, CA 94607
  (415) 540-2713
- Local Office of Emergency Service

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California Office of Emergency Services